Creativity and Logic in Primary-School Mathematics: a View from the Classroom

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This article focuses on primary (elementary) school teachers' perceptions of creativity and logic and their places within mathematics education. It explores some themes arising from the ways in which creativity and logic were talked about during semi-structured interviews, addressing the extent to which the teachers believed that mathematics was creative or logical and whether these two characteristics were seen as mutually compatible or exclusive.

I will discuss here a small selection of data from a larger project looking at English generalist primary school teachers' personal and professional relationships with mathematics (Bibby, 2001). This data sample comes from a series of forty in-depth interviews conducted with seven inner-city primary school teachers from three schools (Alice, Annie, Elizabeth, Helen, Janet, Joanne and Owen) over the period 1997-2000.

Data from one of the semi-structured interviews is used particularly here. In this interview the teachers were asked to order a series of cards - developed from the SIMS research (Robitaille, 1992); see Bibby (2001) for a full description - to reflect their importance in the teaching and learning of mathematics in primary schools. While notions of creativity and logic were prompted, this discussion focuses on the ways in which these words were interpreted by the teachers.

While mathematics is undoubtedly a creative endeavour, the ways in which it is taught in English primary schools seems not to reflect this. Only one teacher, Joanna, saw no distinction or separation between logic and creativity since "logic is creative". For the other teachers, creativity and logic were seen as separate things. Although it was generally felt that both may have a place within mathematics, this was far from certain and the place that each might occupy was not always clear. The ideas of creativity and logic seemed to be those 'common sense' understandings made use of in conversation rather than deploying technical definitions.

In attempting to describe a pupil able to think creatively in mathematical contexts, Haylock (1987) observes:

> It can be imagined that the pupil lets the mind run freely over the whole range of available mathematical skills and knowledge previously learned, confident that these can be called upon without difficulty and anxiety. [...] Such a pupil would not guess wildly, but may be more prepared to trust a personal judgement in a mathematical situation in which there is some degree of uncertainty. (p. 58)

It is the degree of fit between what the teachers said and this general description that is tentatively explored here.

Logic and the discourses of primary mathematics

The idea of logic is powerful, perhaps particularly so when coupled with mathematics; but what do primary teachers mean by 'logic'? The technical, mathematical meaning of logic relates to deduction, the derivation of new truths from older truth statements (Ernest, 1991, pp. 4-7). In no sense did deduction form part of the discourse of primary school mathematics (hereafter PSM) or of the teachers' understanding of logic. The 'common-sense' understanding of logic they demonstrated seems to relate more to a conception of reasoning and separated from the 'technical' understanding by the association of the adjective to the noun. Logic - the noun, the 'technical understanding' - is about deduction, reasoning and justification. The associated adjective - logical - relates directly to the validity of these processes of reasoning and justification. These 'common-sense' understandings seem to uncouple the meaning of the adjective from the noun.

The place of logic

Annie was the only one of the interviewees who was confident about her own mathematics (she was also the only one with an 'A'-level in the subject) and yet her feelings about the role of logic were ambivalent. She talked about her enjoyment of mathematics and seemed to imply that a step-by-step, methodological notion of logic provided her with security, a place with no nasty surprises.

> [Mathematics] is perfect, it's closed, it's contained, you can do it and it's done, you know it's done, no question about it, it's done. Tidy, that sort of thing. I think [that's] what people are attracted to towards maths - it's very deeply psychological - maybe because I have deep insecurities and in maths I find a secure place where things work and things are orderly and that's why I like it

She described her own experience of being taught mathematics which would appear to link her enjoyment and sense of security to an authoritarian style of teaching which she now questions in relation to those that she teaches.

> when I was at primary school [...] we were taught *the* method, how to do logically long multiplication and

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> division and that was it and then you were just given pages of practice to do But nowadays we approach numbers from all angles [ ] and I think it's having an effect, it's really good.

The logic here is the systematic, step-by-step conception of logic rather than the logical reasoning of deduction, argument or justification. She also splits the content from the methods and sees method as a given. There seem to be two kinds of logic being invoked: there is the step-by-step, systematic logic that relates to methods.

There is also a logic which pertains to the structure of mathematics. She questions the need to teach the logical structure of mathematics, identifying this with what she called the 'higher levels' section of her aims of mathematics. She explains that, unless you become interested in studying mathematics at these 'higher levels', you do not need to understand that there is a logical structure to maths, you just need to be able to use it. This contradiction was unexplored and unexplained in the interviews.

A ready source of external authority was seen as useful for mathematics although not for creative subjects:

> In English or something I was good at - you know I had the confidence then to feel that if it there was maybe a poem or, you know, I don't know, something similar I didn't understand, I'd have the courage to go and question it. Whereas in maths - oh - it would be another thing that I can't do. (Janet)

Such a train of thought might lead to the subjugation of chaotic or lengthy personal methods to the superior efficiency of the step-by-step logic exemplified by formal algorithms:

> I would probably be able to work it out the long way round and then be able to condense it to a more useable sort of logical approach (Elizabeth)

Those formal algorithms which are given by the teacher and handed down from generation to generation – sequences for producing solutions compressed into opacity – are equated with logic because of their proximity to the step-by-step understanding of logic. So to be logical in the discourse of primary mathematics is to be systematic, to think things through carefully with a methodical step-by-step, 'recipe' approach. This systematic, step-by-step understanding of logic is very different from 'technical' notions of logic as involving deduction and justification.

Creativity and the discourses of primary mathematics

The objectivity of logic contrasts with the apparent subjectivity of the creative process. An 'everyday' picture of creativity is of unfettered, personally authored and validated work; it is about the sharing of internal worlds of imagination and individual voice. At its most fundamental, creativity is about the generation or birth of new objects or ideas. However, notions of creativity are difficult to pin down.

The National Advisory Committee on Creative and Cultural Education (1999) gives five pages to developing a definition of creativity. They say it is:

> obviously to do with producing something original [. but that it is] not unique to the arts. It is equally fundamental to advances in the sciences, in mathematics, technology, in politics, business and in all areas of everyday life. (pp. 24-25)

They are wary of *élite* definitions which privilege the remarkable productions of the exceptionally talented few and prefer a *democratic* definition in which all people are seen as:

> capable of creative achievement in some area of activity (p. 27)

Creativity is not, they say, simply a matter of letting go.

> Serious creative achievement relies on knowledge, control of materials and command of ideas (p. iii)

Creativity, then, is rooted in discipline and can be applied in the whole range of human endeavour.

A more playful notion of the creative process is mooted by Guy Claxton (1997):

> In the gloaming of the mind, if one is quiet and watchful, one can observe the precursors of conscious intelligence at play, and in so doing may be lucky enough to catch the gleam of an original or useful thought. As Emerson said, talking of creativity in his essay on 'Self-reliance': 'A man should learn to detect and watch that gleam of light that flashes across his mind from within [..] In every word of genius we recognise our own thoughts; they come back to us with a certain alienated majesty' (p. 81)

His description of the creative process echoes that described by Haylock in his study of mathematical creativity in school children. This general understanding of creativity explored briefly here is not far removed from the implicit understandings of the teachers I interviewed, although, as we shall see, their understandings did not extend to Haylock's in relation to mathematics.

Owen was one of those who contrasted the teaching of mathematics and creative subjects in his efforts to verbalise his beliefs about mathematics:

> Well, like, for instance, I think in writing or in art and things like that, [the children] have actually got to be less sort of egocentric and really see things from another you know - yeah, get outside themselves a bit and really see things in a different way. Whereas in maths there is an order to it [.] and a logic and a - like patterns to be seen and understood you know [.] you've got to see order in things rather than seeing how diverse things can be.

Here, Owen talks about creativity in ways familiar from Haylock's description of creative thinking - "letting the mind run freely" - but not in the context of mathematics. Owen's comment gives us a sense that he is so tied to the processes within maths that he is unable to step beyond them, that in relation to mathematics we are chained to methods, unable to unshackle ourselves and trust our freed minds.

The place of creativity

For all the teachers (apart from Joanna), the place of creativity in mathematics was problematic, indeed the only place for creativity seemed to be within problem solving. There was a general sense of vagueness - of creativity being 'a good thing', but its role and nature being unclear. Again, Haylock (1987) indicates part of the problem when he points out that rigid mind-sets can prove counter-productive in problem-solving contexts:

> Much of the interest here [thinking about children's mathematical creativity] lies in the transition from the incubation to the illumination stages in which an insight into the solution of a problem is gained. Often this insight fails to take place because the person concerned is subject to [...] a mental set. Thinking is funnelled along inappropriate lines (Duncker, 1945). In problem solving this is the antithesis to flexibility, a key factor in creative thinking (p. 49)

Among the teachers I interviewed, such flexibility was not mentioned. As Haylock suggests, such a failure to recognise the importance of flexible thinking would act against developing creativity within mathematics. If logic has been uncoupled from notions of argument and justification, then perhaps this is unsurprising.

Elizabeth's hierarchical view of the subject privileged logic and made no allowance for creativity and yet she wanted it there to strengthen the 'tool-box':

> I think it's very important that you can relate the number work to the problem solving at this stage, 'cause it helps that logical thinking which is then also used in other subjects [...] It's something that links in an awful lot to the rest of the curriculum [...] The creativeness I do think is important, but in a way that sort of is the opposite to the logic. [...] I suppose I automatically looked at that [a card labelled 'creative'] and thought, in some ways maths is basically governed by a series of rules therefore you can't be too creative. But I think the creativeness is very important in terms of approach to problem solving and the logic. [...] This confidence in the attack, the skills.

So you need logic to know how to perform mathematics, but you also need creativity to spot the best line of attack; a belief shared by Helen who describes a child as very confident, so when he's presented with something new he is not thrown by it and can be quite logical about working out what he needs to do.

The extent to which Elizabeth and Helen were talking about the kind of mathematical creativity that Haylock exemplified is open to question. Mathematical creativity would seem to rely on making associations (Have I seen a problem like this before? What does it remind me of? How might I use that?), which contrasts with the kind of creativity that is generally implicated in primary school mathematics. This PSM notion of creativity, which relies on a recipe for solving (Is it an add? How do I add?), seems to be 'logical' but not creative.

This might link to Janet's inability to connect creativity, which she saw as an extremely important life skill, to mathematics and her strong desire to focus on problem solving and investigational work which she nevertheless felt unable to approach in her teaching:

> I would like to be able to think that I can encourage children to be able to think creatively and I know [...] I feel that there is a right and wrong answer.

That the place of problem solving within the tension between creativity and logic might hold an important key for teaching mathematics and offering a resolution to the tension was only recognised to a limited extent by the teachers. It raises a question: would connecting creativity, warmth and emotional responses back into mathematics, logic and individualism bring mathematics back to life for these teachers or stop it from being seen as maths?

The place of problem solving

All the teachers insisted that problem solving was the home of creativity within PSM. However, the notion of creativity being suggested by the teachers was not the flexible mathematical creativity of association suggested by Haylock (1987), but rather the 'logical' creativity of 'recipe', algorithmic knowledge (if it is an add, I do this). While association creativity appears to be rooted in the discipline, the 'recipe creativity' of PSM seems rooted within the methods associated with the discipline and to be less than creative. This 'logic'-based, 'recipe creativity' subverts creativity to the dominant metaphor of mathematics as 'logical' in a systematic, step-by-step way.

Problem solving was felt to be the place where mathematics might break away from its strict adherence to logic, in order to allow some room for creativity. All the teachers (except Joanne) struggled with their understanding of creativity in relation to mathematics. There is apparently no room for flexibility of thought since thought processes are given (by rules and algorithms) but flexibility is needed - a real conundrum that pervading beliefs keep them trapped within:

> It is clear that children [and teachers] may show fixation in mathematics by the continued use of an initially successful algorithm, even when this becomes inappropriate or less than optimal. (Haylock, 1987, p. 50)

The contradictions that surround creativity and logic in the context of problem solving highlighted issues relating to control over solution strategies. All the teachers I interviewed were clear that this was the place where mathematics could be creative. The power of the notion of mathematics as 'logical' seems to over-ride and squash any creative potential there may be. The flexibility of thought, a willingness to engage with justification, is subordinated to the 'recipe' of processes which are laid down by rules and algorithms.

Implications of a tension between creativity and logic

All but one of the teachers in my sample privileged logic over creativity. Attraction to the supremacy of the notion of logic held by the teachers (algorithmic, step-by-step, non-creative, a tool to facilitate procedural thinking) suggests a reliance on external authority. While those in possession of a

personal sense of mathematical authority may be able to wield logic creatively to challenge external authority, for those who experience mathematics as about external authority and for whom the rules are right and work because someone else says so it is quite another matter As Hilary Povey (1997) suggests, this can lead to the silencing of the personal voice and, viewed from a position of silence:

> reason [logic?] is only the handmaiden for the inculcation of established procedural knowledge validated by external authority. (p. 334)

Different conceptions of mathematics imply different relationships with the notions of creativity and logic discussed above. For the product-oriented teacher (Platonist or instrumentalist), logic (whether conceived of as a system of rigorous proof or as a methodical use of tools) may provide the ultimate confirmation that mathematics is a self-sustaining body of knowledge whose meaning is:

> independent of time and context [...] associated with concepts rather than conceiving, a fixity to which the learner converges (Brown, 1994, p. 141)

This would be a place in which creativity (at the school level, at least) is generally unwelcome For those with a process orientation, creativity is an inherent part of negotiating meaning and coming to know, and logic has a softer role to play in making the complex general. Thoughts of children working creatively within mathematics might be threatening to teachers who were themselves reliant on external authority.

Conclusion

To return to the opening quotation, Janet highlighted 'creativity' as the most important card in the interview, although she appeared to have dismissed the mathematical context. Creativity was a *life skill*; logic was not. (Indeed it was a card that summoned up such fear that she was unable to place it anywhere and had to hide it)

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She added that she felt she did not have enough understanding of mathematics to know whether it was more creative than logical or more logical than creative, but, for her, logic was strongly associated with science, maths and 'brainy people'.

While it might be a step towards more mathematical creativity, the 'recipe' creativity of the teachers I interviewed *funnelled thinking along inappropriate lines* and severely limited their personal and pedagogic understanding of the potential for creativity within mathematics. For them, 'letting go' might not be possible within their current conceptions, not least because of unaddressed fears and a lack of faith in what it might achieve

References

Bibby, T. (2001) *Primary School Teachers' Personal and Professional Relationships with Mathematics,* Unpublished Ph D. thesis, London, King's College, London

Brown, T. (1994) 'Towards a hermeneutical understanding of mathematics and mathematical learning', in Ernest, P. (ed), *Constructing Mathematical Knowledge: Epistemology and Mathematical Education,* London, Falmer Press, pp. 141-150

Claxton, G. (1997) *Hare Brain Tortoise Mind: Why Intelligence Increases When You Think Less,* London, Fourth Estate

Ernest, P. (1991) *The Philosophy of Mathematics Education.* London, Falmer Press.

Haylock, D. (1987) 'Mathematical creativity in school children', *Journal of Creative Behaviour* **21**(1), 48-59.

National Advisory Committee on Creative and Cultural Education (1999) *All Our Futures: Creativity, Culture and Education,* London, DfEE

Povey, H. (1997) 'Beginning mathematics teachers' ways of knowing: the link with working for emancipatory change', *Curriculum Studies* **5**(3), 329-342.

Robitaille, D. (1992) 'Characteristics of schools, teachers and students , in Burstein, L. (ed.), *The IEA Study of Mathematics III: Student Growth and Classroom Processes,* Oxford, Pergamon Press, pp. 29-57